

piezoelectric/electrostrictive film element in<sup>a</sup> manufacturing method of various film devices using the ceramics. ✓

Considering<sup>the</sup> ultimately obtained film quality, methods mainly used for the ceramic sol solution are dip coating, spin coating, electrochemical oxidation/reduction etc. while methods used for the ceramic oxide powder are various printing, molding, electrophoretic deposition (EPD) etc. ✓

Among these methods, EPD is a method to mold an elaborate film, using<sup>making use of</sup> the polarization of each component by electric polarity and the stacking property of solid particles. ✓

In the EPD process using a ceramic oxide powder<sup>shown in block d.</sup> in Figure 2, ceramic particles of average diameter not less than 1  $\mu\text{m}$  made by<sup>a</sup> solid phase process are dispersed in<sup>an</sup> adequate dispersion medium of water or organic dispersant. Then, they are mixed with a pH-controlling medium to make a sol solution controlled<sup>in</sup> of surface electric charge, which the colloidal suspension is used for ceramic to move to<sup>a</sup> cathode or anode to form a film on a substrate. <sup>This</sup> film is vapor deposited by thermal treatment above 1000°C, eventually to form the film. ✓

EPD like this has<sup>an</sup> advantage to make a high quality film unrestricted<sup>in</sup> of area or thickness, using a simple equipment. ✓

But ~~there needs~~ a separate operation<sup>is needed</sup> to disperse powder using a dispersant, in order to secure dispersibility, because<sup>a</sup> large particle diameter powder is used<sup>Also,</sup> and there is inevitability<sup>a</sup> problem of high temperature thermal treatment to get material property peculiar<sup>to the</sup> of ceramic, because<sup>the</sup> formed film property is similar to<sup>the</sup> bulk. ✓

#### SUMMARY OF THE INVENTION



✓ an organic solvent; dispersing by mixing <sup>with the ceramic sol solution</sup> the suspension in which the ultrafine ceramic oxide powder is dispersed ~~with the ceramic sol solution~~; forming a piezoelectric/electrostrictive film element by submerging a substrate into the suspension <sup>in</sup> which the ultrafine ceramic oxide powder and the ceramic sol solution are mixed and then by performing electrophoretic deposition; and thermally treating the piezoelectric/electrostrictive film element at 100-600°C, so that the solvent is removed by the thermal treatment and ~~the~~ bonding among the ultrafine ceramic oxide powder particles is induced, while the ceramic sol acts as a reaction medium on the surfaces of the ceramic oxide particles. ✓

Also the present invention features a piezoelectric/electrostrictive film element produced by a method comprising the steps of: preparing a solution or a dispersed mixture containing constituent ceramic elements by dissolving or dispersing the raw material of constituent ceramic elements in a solvent or dispersion medium; preparing a mixed solution by adding citric acid into the solution or the dispersed mixture in which the constituent ceramic elements are dissolved or dispersed; getting ultrafine ceramic oxide powder of particle size less than 1  $\mu\text{m}$  with uniform particle diameter size distribution by forming ceramic oxide without scattering over, by <sup>a</sup> nonexplosive oxidative-reductive combustion reaction by thermally treating the mixed solution at 100-500°C; preparing a suspension by dispersing the ultrafine ceramic oxide powder in an organic dispersant; preparing <sup>a</sup> ceramic sol solution by ~~dissolving~~ constituent ceramic elements of <sup>the</sup> same or similar